

XXVI.—On the Development of the Lampreys.

By AUGUST MÜLLER*.

M. AUGUST MÜLLER has observed some interesting facts in the history of the small Lamprey, which occurs abundantly in the fresh waters near Berlin. The animals appear suddenly at the spawning season in clear brooks, where they glide about amongst the stones, or, attaching themselves to these by the mouth, float in the stream. After spawning they disappear entirely; and, during the period of their occurrence, none but full-grown individuals are to be seen.

At the spawning time they are seen in small groups of ten or more individuals, and the spawning is effected in the following manner:—The male fastens with his mouth upon the neck of the female behind the eyes, and then twists his body half round towards her belly, when the emission of the ova and seminal fluid takes place.

The recently emitted ova are less than half a line in diameter, white, slightly yellowish, and enclosed in a thin gelatinous capsule, which is difficult of detection even after swelling in water. The segmentation is complete, as already stated by Schultze†, and commences about ten hours after fecundation. The process is described much in the same terms as by Schultze: the yelk is divided into a smaller upper, and a large lower portion, from the former of which the embryo is developed; the upper portion is composed of small, and the lower of large masses, and the centre is occupied by a cavity, which afterwards becomes smaller, and gradually draws towards the head of the embryo.

The hinder end of the egg becomes flattened, and on the upper part of this flat space the anal opening makes its appearance, surrounded in front and on the sides by a horse-shoe-shaped ridge, and from this a narrow canal is soon traceable half across the egg, beneath the region of the dorsal cord. The brain and spinal cord then become more strongly developed; they are divided by a longitudinal furrow, which soon closes again. The dorsal cord never advances further than between the labyrinths of the ears. Its contents appear striated towards the period of exclusion, as is also the case in the embryos of some bony fishes; but in the Lamprey the striæ consist of series of cells. The head grows out, and exhibits two lateral swellings, separated by a cleft in the middle. Above these is the cavity of the mouth, and subsequently the nasal opening makes its appearance, and gradually moves from the ventral to the dorsal surface.

* From Müller's Archiv 1856, No. iv. p. 323. Communicated by W. S. Dallas, F.L.S.

† See Annals, vol. xvii. p. 443.

The hinder portion of the body is thick, and contains the vesicular intestine, which is still filled with cells of segmentation. A yolk-sac is never present. The long neck begins to move, and at its base the heart is seen, without a pulsating bulb.

About the eighteenth day the young animal escapes from the egg, when it is white and opaque; but its substance gradually becomes clear, until the movement of the blood can be recognized, when it begins to develop pigment. The brain and spinal cord resemble a constricted thread, thickened anteriorly. The eyes appear as dark points on the sides of the brain. The neck exhibits eight clefts, of which the anterior soon closes, and the cavity of the mouth is united with the branchial cavity by a small opening. The intestine consists of a very fine membrane, covered with a very long bacillar epithelium. Along the back of the intestine runs a fold which receives a vessel, and the ureters rise on the dorsal side of the intestine, and form but few ramifications, in which ciliary movement is seen. The dorsal wall of the mouth has at first two, but afterwards several papillar elevations. In front of the heart is a longish oval organ, like a vesicle, and divided down the middle; this becomes the muscular portion of the sucking apparatus of the Lamprey.

A muscular veil is now developed in the mouth, which prevents the exit of water; and the papillæ of the upper surface of the mouth increase in number and form branches, constituting a sort of net which prevents the entrance of foreign bodies. At this period the author was surprised by the great similarity of his young fishes with those of the genus *Ammocetes*, which occur in the same waters with the Lampreys, and for some time he endeavoured in vain to find any difference between them. After keeping them for two years they died, without exhibiting any tendency to take on the form of their parents; and during the whole of this period they appeared to be genuine *Ammocetes*. The author was therefore led to imagine, that the supposed genus *Ammocetes* was in reality founded upon the young of *Petromyzon*.

To ascertain the correctness of this supposition he sought for *Ammocetes* in course of metamorphosis, and found them in a condition which distinctly showed their intermediate state. The silvery lustre of the skin which distinguishes the Lampreys was already perceptible, and the dorsal fin was elongated. The eye was distinct, but in some individuals was still dull, whilst in others it was perfectly clear. The mouth was narrower than in the true *Ammocetes*; in the latter it measures $3\frac{1}{2}$ millimeters, during the metamorphosis 3, and in the fully developed animal in spring $5\frac{1}{2}$. The distance of the nasal opening from the

anterior margin of the mouth increases in a regular ratio; thus, in the *Ammocætes* it is $4\frac{1}{2}$, in the metamorphosis 6-7, and in the developed *Petromyzon* 9 millimeters. The cleft which separates the upper from the lower lip in the *Ammocætes* was still distinctly present in some animals, but had completely disappeared in others.

The papillæ of the mouth were reduced, but bore no horny armature, and the veil of the mouth still existed in some individuals, especially those which exhibited the cleft between the upper and lower lips most distinctly. When the opening of the mouth was completely rounded, the veil was reduced to a small remnant. The branchial apertures had lost the external valves which in *Ammocætes* prevent the ingress of water; and, in the most developed individuals, these apertures were furnished with a border. The inner branchial apertures were narrowed, but wider than in the Lamprey. In the structure of the œsophagus and other particulars of their anatomy, the animals also exhibited the same intermediate condition. The ova in the ovaries had already become white and opaque; those present in the ordinary *Ammocætes* being transparent. They exhibited the germinal vesicle distinctly, and the testes had developed cells for the formation of spermatozoa.

The metamorphosis goes on rapidly from this point. In sixteen days the yellow teeth made their appearance in many animals, and the sucking apparatus was in action; but it had not acquired its ordinary energy in four weeks in animals kept in confinement.

With this change of form comes a corresponding change in the mode of life. The *Ammocætes* shun the light, and bury themselves in the sand at the bottom of the water. Their respiratory organs are protected by the network in the mouth; they live upon the substances which are collected by it in their mouths, and their œsophagus exhibits ciliary epithelium. The author found the shells of *Bacillaria* in all the *Ammocætes* which he examined. The *Petromyzon*, on the contrary, being well furnished with eyes, seeks the light, and swims about in the clearest water, or fixes itself by suction, when respiration is effected by the ingress and egress of the water through the external branchial apertures.

There is therefore no doubt that the *Ammocætes* are the larvæ of *Petromyzon*, just as the Tadpoles are the larvæ of the Frog. As however only one European species of *Ammocætes* has been described, although we have several species of Lampreys, the author thought it worth while to examine the *Ammocætes* of the River Lamprey. He found this to be exactly similar to that of the small Lamprey above described; both possess a gall-bladder

and otolithes, although these only persist in the small Lamprey. With regard to the Sea Lamprey he could ascertain nothing.

It appears from his observations that the duration of the larval existence must be three years. The spawning takes place in the spring, and only once in the year. In May he took six *Ammocetes*; three small ones, measuring on an average about $2\frac{2}{3}$ inches, and weighing on an average $9\frac{1}{3}$ grains, and the other three measuring about 6 inches, and weighing on an average 87 grains. The three first must have been those of the preceding year, the larger ones must have been two years old; and as they showed no trace of metamorphosis, they could not have produced perfect Lampreys until the third year. Large individuals of *Ammocetes* also occur after the time of the metamorphosis, and these probably do not undergo their change until the fourth year. In the perfect state, the Lampreys live a very short time. Immediately after the spawning season they disappear entirely, and their dead bodies may be seen floating in the water, the ovaries of the females being quite empty. This long duration of the larval state is remarkable, as in the only other Vertebrata which undergo a metamorphosis (the Batrachia) this usually takes place at an early period, and the animal continues to grow long after it has acquired its mature form. The metamorphosis of the Lampreys, therefore, resembles that of the Insects, in which the larval period is the most important portion of the animal's existence,—its principal business in the perfect state consisting in providing for the continuance of the species.

In conclusion, the author refers to the doubts which these observations may induce as to the systematic position of the Lampreys. In the occurrence of the metamorphosis, and the complete segmentation of the yelk, they resemble the Batrachia; and they also differ from the Fishes in the occurrence of a pair of elastic swellings in the *bulbus arteriosus*, one above each semi-lunar valve, whilst the inner wall of the bulb is destitute of the trabecular system which is generally present in Fishes. The structure of the brain also is different from that prevailing amongst the Fishes; but, according to the author's views, the nature of the dorsal chord and its appendages is decidedly piscine. The result of his examination of comparative characters is, in fact, to leave the Lampreys exactly in their former position. He promises a longer memoir on this subject, illustrated with figures.